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GIFT OF
Univ.

Hough '04.
Triplex Pump
59

THESIS.

...sses and Efficiencies of the ...leming Triplex Pump.

Fredk L. Hough, Jr.

June 1904.

E 378.748
P O S 1904.3

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The object of these tests was to determine the various efficiencies and losses of the Deming Triplex Pump in the Mechanical Lab'y. of the University of Pennsylvania

A pumping engine can only be held responsible for the work done from the time the water enters the pump until it leaves, and must not be charged with losses resulting from long supply or delivery pipes or other conditions foreign to the pump itself.

For this reason, the pressure and vacuum gauges, or other means of measuring the head, should be placed as close to the pump as possible.

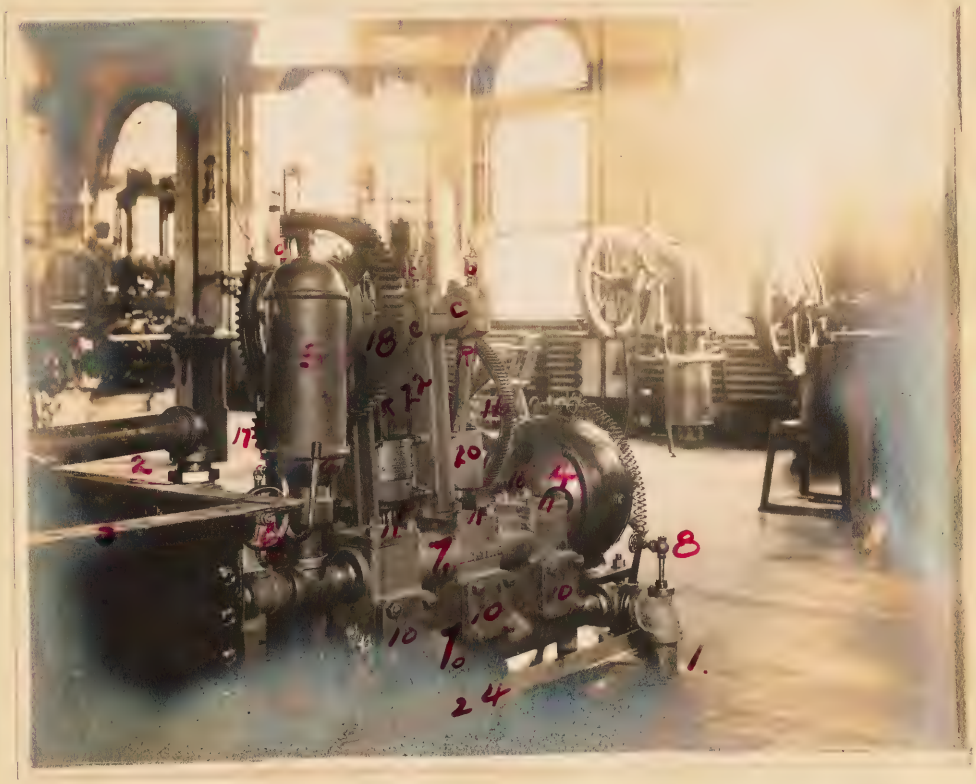
H. S. F. Lewis
Sr. J. Univ.
31 May 1948.

The pump tested is a Triplex 4"×4" manufactured by the Deming Pump Co., Salem, Ohio. The power is obtained from a Diehl 3 H.P. shunt wound motor, Type C 75. manufactured by The Diehl Mfg. Co., Elizabeth, N. J.

On pages 3, 4, & 5 are shown illustrations of the pump and piping but without the gauges, indicators etc., that were used during the tests. The numbers (in red) on the illustrations refer to the same objects in every view.

As the name of the pump indicates, there are three plungers, singe acting, working ordinarily in the cylinders I-II & III (see illus.) The plungers are outside guided and outside packed (20 & 21) and

23
16
4
25
28
5
9
2
6
III
II
I
24


18
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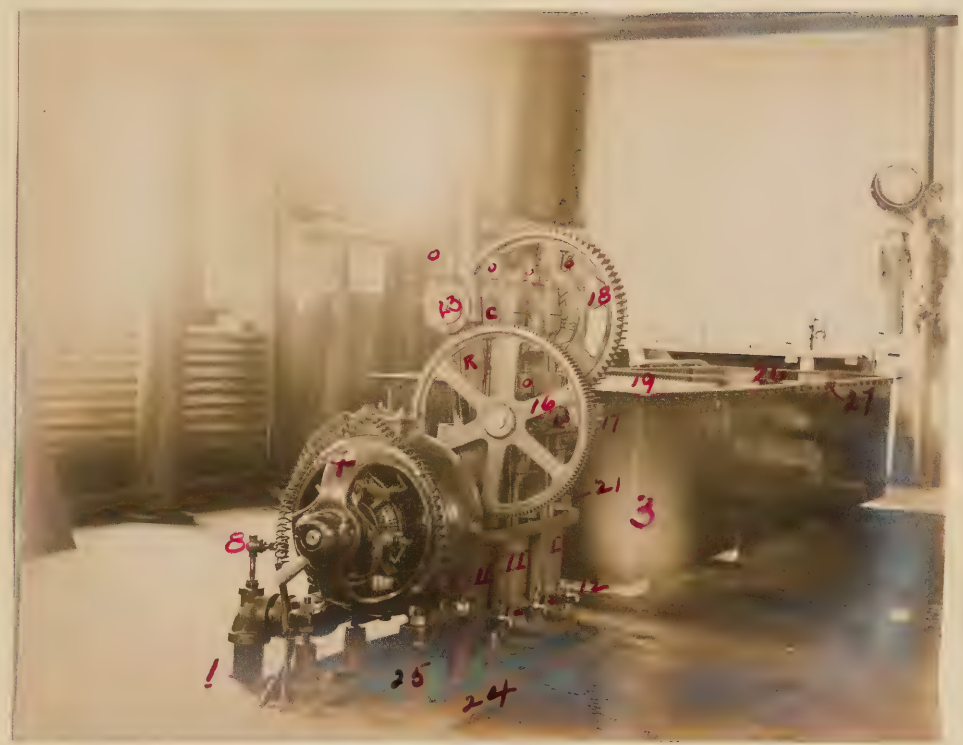
1.


0
13
C
18
K
19
25
27
16
17
21
3
8
11
12
1
25
24

driven by the connecting rods, R.R.R. from the steel crank shaft 23. by the cranks, C-C-C, which are set at angles of 120° with one another. Thus one plunger, at least, is pumping all the time; this combined with the arch of the large air chamber 5, insures a practically uniform flow of water. The pressure gauge attached at 9. shows little or no fluctuations in pressure, showing there is constant pressure in the supply pipe.

The main bearings are at B-B, All the bearings are large, well lined with babbitt-metal and oiled from automatic oil cups, o.o.o.

The crank, which is in one piece, is supported by large strong

castings, 22,-22, which are part of the main casting below, of which the three cylinders form a part.

The castings, 20--, forming the guides for the plungers, as well as the bearing blocks, 14, for the pinion shaft, 13, are bolted on to the uprights, 22-22.

"7" is the valve chamber. The discharge valves in 7, can be removed by means of the cover plates, 10-10-10; the suction valves in, 7, through 10-10-10. This chamber has suction and discharge openings on both sides of the pump. The ones not in use are closed by plugs (see 7 on page +)

In the larger sizes of these

pumps, the valve chamber can be attached on either side of the pump. The valves are large and amply strong for heavy duty.

24 is a casting for catching grease and water from the pump and can be provided with overflow pipes at 28-28. However, owing to the good packing and tight fit of the plungers, there is no drip to speak of. Attached to 24 are the supports, 25-25, upon which the motor is placed between jam-nuts as shown in the illustrations.

The motor transmits power to the pump through the raw-hide pinion 15, (26 teeth) on the motor shaft, the cut gears 16 (144 teeth) and 17 (15 teeth), on the counter shaft, 13,

and the cut gearing, 18, (76 teeth) on the main shaft, 23.

The pump shaft 13, is adjustable from and toward the main shaft

The suction pipe, #1, is 2½" in diameter; the delivery pipe, 2, is 2" in diameter and discharges through the valve, 6, into the tank 3, through the screen, 19, and thence over the weir, 26.

Arrangements for Testing.

Revolutions were obtained from the motor shaft by a hand speed-indicator, and from the pump by means of a continuous counter attached to one of the connecting rods. One reading acts as a check on the other, the reduction in speed

between the motor and pump being known from the number of teeth in the gears.

The vacuum gauge is attached at 8, and indicates the suction which varies according to the height of water in the supply tank (due to other pumps; the water delivered over the weir, 2, returns directly to the supply tanks).

The pressure-gauge is attached at 9, between the pump and the valve, 6, and indicates the additional head required to pump the water to the outlet of the delivery pipe. Variations in pressure were obtained by the degree of throttling of the valve, 6.

The quantity of water delivered

per second was determined from readings of the hook gauge placed at Z7, about 4' from the crest of the weir

The screen at 9 stopped all disturbances in the surface of the water and enabled the readings of the gauge to be determined to ½ of a thousandth of a foot.

Attached to the wall a few feet from the motor are two ammeters (not shown in the illustrations) one in the armature circuit and the other in the field circuit.

At 12-12-12 on the cylinders are shown three cocks used in priming the pump. These were removed and indicator cocks

attached in their places through two nipples, a reducing coupling and an elbow.

Motion was given to the indicators through cords attached to inverted "L" shaped pieces of 3/8" iron rod attached to the top of the plungers. The plungers are hollow cylinders 14 3/8" long, 4" in diameter in the cylinder and 4 1/4" in the guides. The walls are 1/2" thick. 1/4" holes were tapped in these walls on the side toward the indicators and these "L" shaped pieces screwed into the holes with the horizontal part of the rod projecting about 4" out over the guides far enough to be just vertically over the pulleys of the

indicators. This gives a fairly long card, nearly 4", but the drum motion is so slow this is an advantage rather than a detriment.

Test.

As before stated, the principal object of these tests was to determine the efficiencies, mechanical, hydraulic, and total, and to separate the losses into those resulting from mechanical friction of the working parts of the pump, and those resulting from the hydraulic friction, lift of valves, changes in section of the passage ways, and etc.; these last being lumped together as hydraulic losses

The following data was determined for each test:—

1. Total head, (h).
2. Quantity of water per sec. (Q).
3. Supplied Horse Power (S.H.P.).
4. Indicated " " (I.H.P.).
5. Delivered " " (D.H.P.).
6. Friction " " (F.H.P.).
7. % Friction Loss in Pump.
8. % Hydraulic " " "
9. Mechanical efficiency, (E_1).
10. Hydraulic " , (E_2).
11. Total " (E)
12. Capacity, in gals. per $\frac{1}{4}$ hr. (G)
13. % Slip.

(see p 170 ow. & pp 46 & 47).

Constants.

Quantity of water per sec.

$$Q = \frac{2}{3} c \sqrt{2g} H^3 B = K_1 \times \sqrt{H^3}$$

K_1 $$K_1 = \frac{2}{3} .628 \times 8.025 \times \frac{12}{12} = 2.803$$

c = The coef. in weir formula (P)

H = The head on weir in feet.

B = The length of " " "

Supplied Horse Power.

$$S.H.P. = \frac{T \times 2\pi N}{33000} = T N K_2$$

K_2 $$K_2 = \frac{2\pi}{33000} = .0001905$$

T_1 = Torque of motor in lb. ft.

N = Rev. per min. of motor.

Indicated Horse Power

$$I.H.P. = \frac{P.L.A.N.}{33000} = PNK_3$$

K_3 $$K_3 = \frac{LA}{33000} = \frac{1}{3} \times \frac{\pi \times 4}{33000} = .000127$$

P = Mean Effective Pressure (See under K_6)

Delivered Horse Power.

$$D.H.P. = \frac{Wh}{33000} = \frac{62.42 \times 60 \times h}{33000} = 2hK_4$$

K_4 $\quad K_4 = \frac{62.4 \times 60}{33000} = .1135$

W = The weight of water per min. (in lbs.)

h = The total head

Capacity in gals. per 24 hrs. (actual) (G)

$$G = Q \times 7.48 \times 60 \times 60 \times 24 = Q K_5$$

K_5 $\quad K_5 = 7.48 \times 60 \times 60 \times 24 = 646,300.$

Capacity. (Theoretic)

$$G_1 = \frac{12LA}{231} \times 3N \times 60 \times 24 = K_6 N$$

K_6 $\quad K_6 = \frac{4 \times 47}{231} \times 3 \times 60 \times 24 = 940$

L = Stroke of Pump in feet.

A = Area of piston in sq. inches.

N = Rev. per min. of the pump.

Rev. per. min. of the motor.

$$n = \frac{144 \times 76}{15 \times 26} N = K_7 N$$

K_7 $\quad K_7 = 28.06$

1. Total Head.

The total head is made up of the pumping or pressure head, the suction head, the distance between the gauges, and the velocity head.

$$h = 2.304\,P + \frac{13.6\,V}{12} + 10'' + \frac{v^2}{2g}$$

$$V = \frac{Q}{A} \quad (A = \text{area discharge pipe})$$

Taking the greatest Q, obtained from the tests, viz. .07 cu. ft.

$$V = \frac{.07}{\frac{\pi}{144}} = 3.21 \text{ ft. per sec.}$$

$$\frac{v^2}{2g} = \frac{3.21^2}{64.3} = .16'$$

$$10'' + .16' = .993' \text{ or about } 1'.$$

$$\therefore h = 2.304\,P + 1.133\,V + 1'.$$

P = Pres. gauge reading (corrected)

V = Vac. " "

v = Veloc. in ft. per sec.

2. Quantity of water per second.

$$Q = 2.803\,V\,H^3 \quad (\text{see } p\ 15).$$

H is read by the hook-gauge.

3. S. H. P.

S.H.P = .0001905 T N (see p 15)

The torque is obtained from the equations given on page 34.

4. Indicated Horse Power.

I.H.P = .000127 P N. (see p 15)

One card was taken from each cylinder every five minutes during the test. The mean effective pressure was obtained from these cards from planimeter measurements. The average m. effec. pressure for each cylinder was then obtained from the total number of cards taken

5. Delivered Horse Power

D. H.P = .1135 $\frac{T}{h}$ (see p 16)

The work done by the pump equals the quantity of water pumped in unit time times the distance through which it is pumped.

6. Friction H.P.

This is the work lost by friction in the plungers, bearings, etc. and equals S.H.P. — I.H.P.

7. % Fuction Loss.

This is the ratio of the work done in overcoming mechanical friction and the total work supplied to the pump and equals:-

$$\frac{F.H.P.}{S.H.P.}$$

8. % Hydraulic Loss.

= the ratio of the work done in

overcoming the hydraulic friction and the total indicated work and equals

$$\frac{I.H.P - D.H.P.}{I.H.P}$$

9. Mechanical Efficiency.

This is the ratio between the work indicated in the cylinders and the work supplied to the pump:—

$$E_1 = \frac{I.H.P}{S.H.P.}$$

10. Hydraulic-Efficiency.

is the ratio between the work delivered by the pump and that indicated in the cylinders:—

$$E_2 = \frac{D.H.P.}{I.H.P.}$$

11. Total-Efficiency.

This is the efficiency usually

given in connection with a pump and takes into account all the losses both mechanical and hydraulic. It is the ratio of the work delivered by the pump, to that supplied to the pump

$$E = \frac{D.H.P.}{S.H.P.} = E_1 E_2$$

12. Capacity in gallons per 24 hours.

$$G = 646,300\ d \quad \text{(see page 16)}$$

This is the actual capacity as determined from the quantity of water delivered over the weir and is to be distinguished from the theoretic capacity which assumes the cylinders run full all the time, since it is equal to the product of the plunger displacement and the no. of strokes.

13. % slip.

The "slip" is the difference between the theoretical capacity and the actual capacity.

$$\% \text{ slip} = \frac{\text{Slip}}{\text{Theoret. Capacity.}}$$

Calibrations.

All instruments used during the tests were calibrated with the exception of the continuous revolution counter, which was new and accurate.

The instruments calibrated were:-

I. Pressure Gauge.
II. Vacuum Gauge.
III Indicator Springs.
IV Weir
V Motor and ammeters.

I. Pressure-Gauge.

The pressure gauge, #210 018, was calibrated in the well known way with a Crosby Standard Gauge Tester and gave a very good calibration. The curve is a straight line and includes all the points, so that a very easy way to obtain the pressures accurately corresponding to a number of gauge readings, is to calculate them from the equation of the line which is in the well known form

$$y = ax + b.$$

For the equation and curve with calibrations, see p. 36 & 37

II The vacuum-gauge was calibrated by comparison with a Hg. column.

on a variable vacuum obtained from the air pump on the Snow Jet Condenser in the lower laboratory. The two gauges were connected to the cock on the condenser through "a tee" connection.

The readings of the two, coincided well within the limit of error introduced by very small variations in the vacuum (about ¼") (For readings see p36)

III

Indicator Springs.

Since the springs were to be used cold during the tests, they were calibrated cold on a Crosby Tester,

Three springs were tested: #3071 #3257, & #3382. These were the only springs used, and through

out the tests each spring was used on the same cylinder for every test, as follows: #3371, a 50# spring, on Cyl. #I. (see illus. p. 21); #3257, a 60# spring, on cylinder #II; and #3382, a 50# spring on cylinder #III.

(Exception: Tests 2-5 inc. #3382 and #3257 were interchanged.)

The values of the mean spring scales as determined from the calibrations are: —

#3382 — 48.14# to the inch.

#3257 — 57.84# " " "

#3382 — 50.45# " " "

(See pp 38-40)

IV Weir.

This calibration was to determine the value of "C" in the weir formula: $Q = C \frac{2}{3} \sqrt{2gH^3} B$.

This was done by measuring Q and H and solving for "c".

As there was no means of measuring "Q" by weighing the water, the following method was used :—

The pump was started working slowly and after the conditions were uniform, as determined from the pressure gauge and ammeters, a reading was taken of the hook gauge and the time noted in seconds at which the water just passed the point of the hook. The hook-gauge was then raised and another reading taken about an inch higher and so on until the tank became full. Readings were then taken with the hook gauge of the head

on the weir with the pump still working under the same conditions. From these readings, the rise of the water in the tank per sec. can be obtained and from carefull measurements of the tank, which is rectangular in cross section, the quantity of water delivered by the pump can be calculated.

The mean of the three tests gives "C" as .628, a value which agrees very closely with that given in "Merriman's Hydraulics" for weirs with end contractions. The greatest variation from this mean in the results of the three tests is less than $\frac{4}{5}$ of 1%.

For results and data see Lab. Book 41843

V Motor.

In order to obtain the horse-power supplied to the pump, from the ammeter readings and from revolutions per minute of the motor, the relation between these quantities must be determined from a calibration of the motor.

The motor is a four-pole, shunt-wound, variable speed motor controlled from a Cutler Hammer 3 H.P. controller, # 50639, made by the Cutler Hammer Mf'g. Co., Milwaukee, Wisconsin. This controller has twelve contact-points, giving eleven different speeds over a range of from 800 to 1600 R.P.M. Up to the eighth (8th) point of the rheostat, this is accomplished by decreasing the

the resistance in series with the armature, the field resistance remaining constant; beyond that point, or for the 9th, 10th, 11th, and 12th points, the speed is increased by increasing the resistance in series with the field and thus cutting down the current through the field.

For the last two points, however, the sparking is excessive and the armature soon overheats.

For the eigth, ninth, and tenth points, the motor works very well up to about 2 H.P. (delivered) but not beyond it. i. e. about 250 feet total head can be obtained from the pump, instead of 350 ft. for which it is designed.

Since the tests were run at

different speeds, i.e. with the controller at different points on the rheostat, it was necessary to calibrate the motor for each of the different points.

The motor was disconnected from the pump, the raw hide pinion removed, a cast iron pulley put in its place, and a Prony-Brake test made. Ammeter readings of the currents in armature and field, and torque readings in lb ft. from the brake, were taken for each point on the rheostat above the 8th. and for the second (2d) fifth (5th) and 8th below.

The field currents being the same for points from 2 to 8, the torque readings will be the same

for those points when the armature currents are the same. In other words they will have the same torque curve, which was found to be the case in laying out the curves all the points lying on the same approximate curve.

The curves (see p 42) are drawn with ordinates representing torque in lb. ft. and abscissae the corresponding armature currents. Each curve was drawn for a particular field current which is marked on the curve, and is the field current corresponding to the particular point on the rheostat at which the controller is placed.

For any small changes in the

field current (for any one point on the rheostat) due to the heating of the field, drop in voltage at the terminals etc., the change in torque will be directly proportional to the change in the field current.

The curves obtained as shown on page by drawing mean curves through the points obtained from the brake tests, are straight lines thus bearing out the assumption that the torque is proportional to the armature current

Taking into consideration the statements in the two paragraphs above, it is very easy to obtain the equation showing the relation between field-current, armature current and torque :-

Let T = Torque.

F_0 = The field current marked on curve

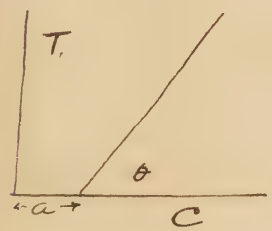
F = " " " as obtained during a test.

C = The armature current.

K = The tangent of θ.

a = Abscissa for the point whose torque is 0

For a point on the curve whose torque is T with a field current F_0, when the current changes by a small amount to F the torque is $\frac{F}{F_0} \cdot T$ from the statement on the previous page.



For a current F_0 :-

$$T = K(C - a_1$$

For a current F :-

$$T = \frac{K F}{F_0}(C - a)$$

$$= K_1 F (C - a)$$

To obtain K for any of the lines, take the ratio of the ordinate for any point to its abscissa minus "a".

The following results were obtained from the measurement of the curves on p 42. See p. 44 for results.

Rheostat Point	a	K	K_1	F_0
2 – 8	4.06	.615	.818	.70
9	3.6	.4875	.891	.58
10	3.84	.482	.925	.52
11	4	.466	1.083	.43
12	4	.444	1.083	.41

Equations.

2 – 8	$T = .878\ (C - 4.06)$
9	$T = .891\ (C - 3.6)$
10	$T = .925\ (C - 3.84)$
11	$T = 1.083\ (C - 4)$
12	$T = 1.083\ (C - 4)$

Instruments.

Indicators # 3071, # 3257, & # 3382

Spring " " "

Pressure Gauge # 210,018.

Vac. " 191,314.

The counters and hook-gauges are permanently attached.

On pages 46 & 47 are given the logs and data & results of all the tests 1-17 inclus. in the order in which they were made.

On page 48 is the log of test # 1 and is the same form as that used during the tests.

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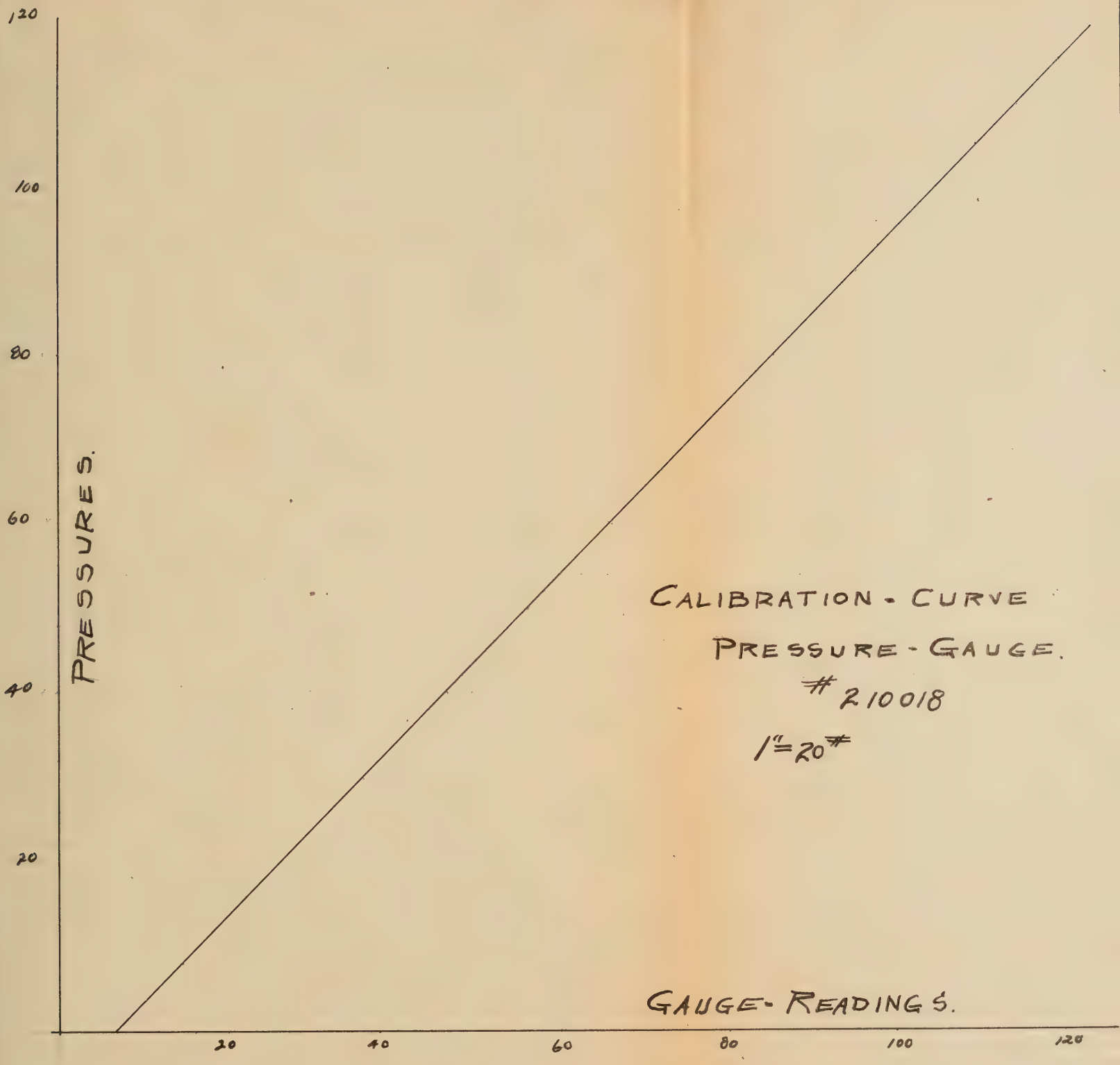
Calibration of Pressure Gauge #210018. - Apr. 25.

UP		DOWN.		MEAN.	
P.	G	P.	G	P.	G
0	6	115	120	0	6.5
5	10.5	110	115.5	5	11.25
10	15.5	105	110.5	10	16.25
15	20.5	100	105.5	15	21.25
20	26	95	100.5	20	26.50
25	31.5	90	95.5	25	31.5
30	36	85	90	30	36.5
35	41.5	80	86	35	41.75
40	46	75	80.5	40	46.25
45	51	70	75.5	45	51.25
50	56.5	65	70.5	50	66
55	60.5	60	66.5	55	60.5
60	65.5	55	60.5	60	66
65	70.5	50	55.5	65	70.5
70	75	45	51.5	70	75.25
75	80	40	46.5	75	80.25
80	85	35	42	80	85.5
85	90	30	37	85	90.
90	95.5	25	31.5	90	95.5
95	99.5	20	27	95	100
100	104.5	15	22	100	105
105	109.5	10	17	105	110
110	115	5	12	110	115.25
115	120	0	7	115	120.

H_1 −	H_2 =	H.	V
17.85	1.35	16.5	16.5
16.6	2.7	13.9	13.8
15.1	4.1	11	11
14.2	5.1	9.1	9
12.9	7.5	5.4	5.5

Calibration of #191,314 Vacuum Gauge by Hg. Manometer, 3-19-04

P = Pressure
G = Gauge Reading
V = Vacuum "
H = Manom. "


120
100
80
60
40
20
PRESSURES.
20
40
60
80
100
120
GAUGE-READINGS.
CALIBRATION-CURVE
PRESSURE-GAUGE.
210018
1" = 20#

CALIBRATION OF INDICATOR-SPRING

3071 (COLD) Mar. 7th. 1904.

PRES.	ASCEND.	DESC.	SPRING-SCALES ASC.	SPRING-SCALES DESC.	MULTI-PLYERS.	PRODUCTS ASC.	PRODUCTS DESC.
10	8.5	10.5	42.5	52.5	1	42.5	52.5
20	17.5	20.5	43.8	51.2	4	195.2	204.8
30	27.5	30	45.8	50	2	91.6	100
40	37.5	39.5	46.9	49.3	4	187.6	197.2
50	47	48	47.	48	2	94	96
60	56.5	58	47.1	48.3	4	188.4	193.2
70	66	67.5	47.2	48.2	2	94.4	96.4
80	75	77.5	46.9	48.4	4	187.6	193.6
90	85	87	47.2	48.3	1	47.2	48.3
				SUM	24	1128.5	1182.0
				MEAN	47.02	47.02	49.25

47.02
49.25
2)96.27
48.14 = the Mean Spring Scale

CALIBRATION OF INDICATOR - SPRING # 3257

March 7. '04.

PRES.	ASC.	DESC.	SPRING-SCALES ASC.	SPRING-SCALES DESC.	SIMPSONS MULTIPLY. ERS.	PRODUCTS ASC.	PRODUCTS DESC.
10	7.5	11	45	66	1	45	66
20	18	18	54	54	3	162	162
30	28	30	56	60	3	168	180
40	38	40.5	57	60.8	2	114	121.6
50	48.5	49	58.2	58.8	3	174.6	176.4
60	57.5	59	57.5	59	3	172.5	171
70	68.5	68.5	58.8	58.8	2	117.6	117.6
80	77.5	79	58.2	59.3	3	174.6	171.9
90	88	88	58.7	59.3	3	175.1	177.9
100	98.5	99	59.2	59.4	1	59.2	59.4
				SUM	24	1362.6	1415.8
				MEAN		56.78	58.99

56.78
58.99
2) 115.77
57.89 # per 4/in. = Spring Scale

CALIBRATION OF INDICATOR-SPRING # 3382.

PRES	ASC.	DESC.	SPRING-SCALES ASC.	SPRING-SCALES DESC.	SIMP. MULTIPLYERS.	PRODUCTS. ASC.	PRODUCTS. DESC.
10	11	12.5	55	62.5	1	55	62.5
20	20	22	50	55	4	200	220
30	30	32	50	53.3	2	100	106.6
40	39	40	48.8	50	4	195.2	200
50	49	50.5	49	50.5	2	98	101
60	54	60.	49.2	50	4	196.8	200
70	68.5	69	48.9	49.3	2	97.8	98.6
80	78.	78	48.8	48.8	4	195.2	195.2
90	88.5	91	49.2	50.6	1	49.2	50.6
				SUM	24	1187.2	1234.5
				MEAN.		49.47	51.44

51.44
49.47
2)100.91
50.45# = MEAN SPRING SCALE.

CALIBRATION OF WEIR.

#1. 3-14-04 MECH. ENG. LAB'Y. U.P.

TIME.	H.- TANK	h (WEIR)	TIME	H. Per sec. (TANK)	H. Head on weir.
5-7-20	.400	1.680	5-21	.001706	.070
5-14-10	1.100	1.681	5-23	.001667	.070
5-16-10	1.300	1.681	5-25	.001667	.070
5-19-10	1.600	1.681	5-26	.001688	.070
MEAN.		1.681		.001682	.070

#2.

3-14-'04.

TIME	H. TANK.	h. WEIR.	TIME	H. Per sec. (TANK)	H. Head on weir.
10-32-50	.450	1.688	10-45		.081
10-34-48	.700	1.688	10-50	.002068	.081
10-37-13	1.000	1.688	10-55	.002150	.081
10-38-48	1.200	1.688	11-5	.002083	.081
10-40-24	1.400	1.688	11-10	.002113	.081
10-41-35	1.550	1.688	11-15	.002095	.081
MEAN.		1.688		.002102	.081

TORQUE Lb. Ft.

2d-8th - F.C. = .70
9th - F.C. = .58
10th - F.C. = .52
11th - F.C. = .43
12th - F.C. = .41

TORQUE - CURVES

DIEHL 3-H.P. MOTOR #101759
5-7-04 F.L.H. JR.

ARMATURE - CURRENT - AMPERES.

(NOTE. NO'S ON CURVES REFER TO POINTS ON RHEOSTAT #50639)
F.C. = FIELD CURRENT.

CALIBRATION OF WEIR (CONTIN.)

3-14-04 # 3.

TIME	H. - TANK.	h. WEIR	TIME	H, PER-SEC. (TANK)	H HEAD ON WEIR
11-47-22	.450	.001899	12-0-0	1.684	.075
11-48-41	.600	.001904	12-3-0	1.684	.075
50-26	.800	.001887	12-5-0	1.684	.075
52-12	1.000	.001887	12-8-0	1.684	.075
53-58	1.200	.001887			
55-44	1.400	.001881			
57-30	1.600	.001884			
MEAN.		.001891			.075

MEAN LENGTH. TANK = 10' 5¼"

" WIDTH " = 2' 11¼"

AREA " = 30.66 sq. ft.

$$Q = C \frac{2}{3} \sqrt{2g} H^3 B \qquad B = 10"$$

1st Test $Q = .001682 \times 30.66 = .05157$ cu ft $C = .624$

2d " $Q = .002102 \times 30.66 = .0616$ $C = .627$

3d " $Q = .001891 \times 30.66 = .058$ $C = .633$

MEAN C. = .628

CALIBRATION OF MOTOR. MAR. 21. 04.

TIME	BRAKE	NET BRAKE	ARM. CUR.	FIELD CUR.	RH. POINT.
11-0	2-3-4	.792#	6.	.71	2
11-10	2-6-9	1.0	6.30	"	"
11-15	2-6-9	1.0	6.	"	8
11-30	2-14-9	1.5	6.80	.70	"
11-33	2-14-9	1.5	6.8	"	5
11-35	3-6-9	2	7.5	"	"
11-38	"	2	8.	.69	2
11-40	"	2	7.4	"	8
11-43	3-14-9	2.5	8.2	"	"
11-45	"	2.5	8.3	.68	5
11-50	"	2.5	8.4	"	2
11-53	4-6-9	3.	9.	"	2
11-55	4-6-9	3	9.	"	5
12-0	4-6-9	3.	8	"	8
12-5	5-6-9	4.	10.7	.675	8
12-15	5-6-9	4	10.7	"	5
12-20	6-6-9	5	12.5	"	8
12-25	6-14-9	5.5	13.5	.67	8
12-35	7-14-9	6.5	15.	.66	8
12-40	8-6-9	7.	17.	"	8
2-35	2-3-12	.906	6	.41	12
2-40	3-5-4	2.	8.2	"	"
2-45	4-5-4	3.	10.8	"	"
2-50	6-5-4	5.	15.4	"	"
2-55	6-5-4	5.	14.8	.43	11
3-0	4-13-4	3.5	11.4	"	"
3-5	3-5-4	2.	8.4	"	"
3-10	2-13-4	1.5	7.05	"	"
3-12	2-13-4	1.5	7.0	.52	10
3-14	4-5-4	3.	10.	"	"
3-15	6-5-4	5	14.2	"	"
3-16	7-5-4	6	16.3	"	"
3-18	7-5-4	6	15.8	.575	9
3-19	5-5-4	4	11.7	"	"
3-20	3-5-4	2	7.7	.58	"
3-23		0	4.5	.68	2
3-25		0	4.4	.68	5
		0	4.25	.70	8
3-28		0	4.20	.60	9
		0	4.1	.52	10
3-30		0	4.00	.43	11
		0	4.0	.41	12

LOG OF TEST #1.

Apr 4-'04.

TIME	REV PUMP.	R.P.M.	TIME	F. CUR.	A. CUR.	PRES.	VAC.	H (WEIR)
4			4-0	.65	14	53	16	1.666
			4-5	.66	14	54	"	1.666
			4-10	.65	14	53	"	1.666
4-14-50	2472	43.2	4-15	.66	14	54	"	1.666
4-22-30	2800	43.5	4-20	.65	14.1	55	"	1.000
			4-25	.65	14.3	56	"	1.681
			4-30	.65	14.3	58	"	1.001
4-37-20	3437	43.8	4-35	.65	14.5	59	"	1.667
4-40-50	3588	43.1	4-40	.65	14.5	59	"	1.667
			4-45	.65	14.8	61	"	1.667
4-49-20	3959		4-50	.65	15	62.5	"	1.667
MEAN.		43.7		.652	14.3	56.8	16	1.6665

Weir Zero = 1.5915

Rh. Point # 8

Temp Water 54°

Torque 5.87 #'

Correct Pressure 50.8

Head on Weir .075

Duration of Test 50 min

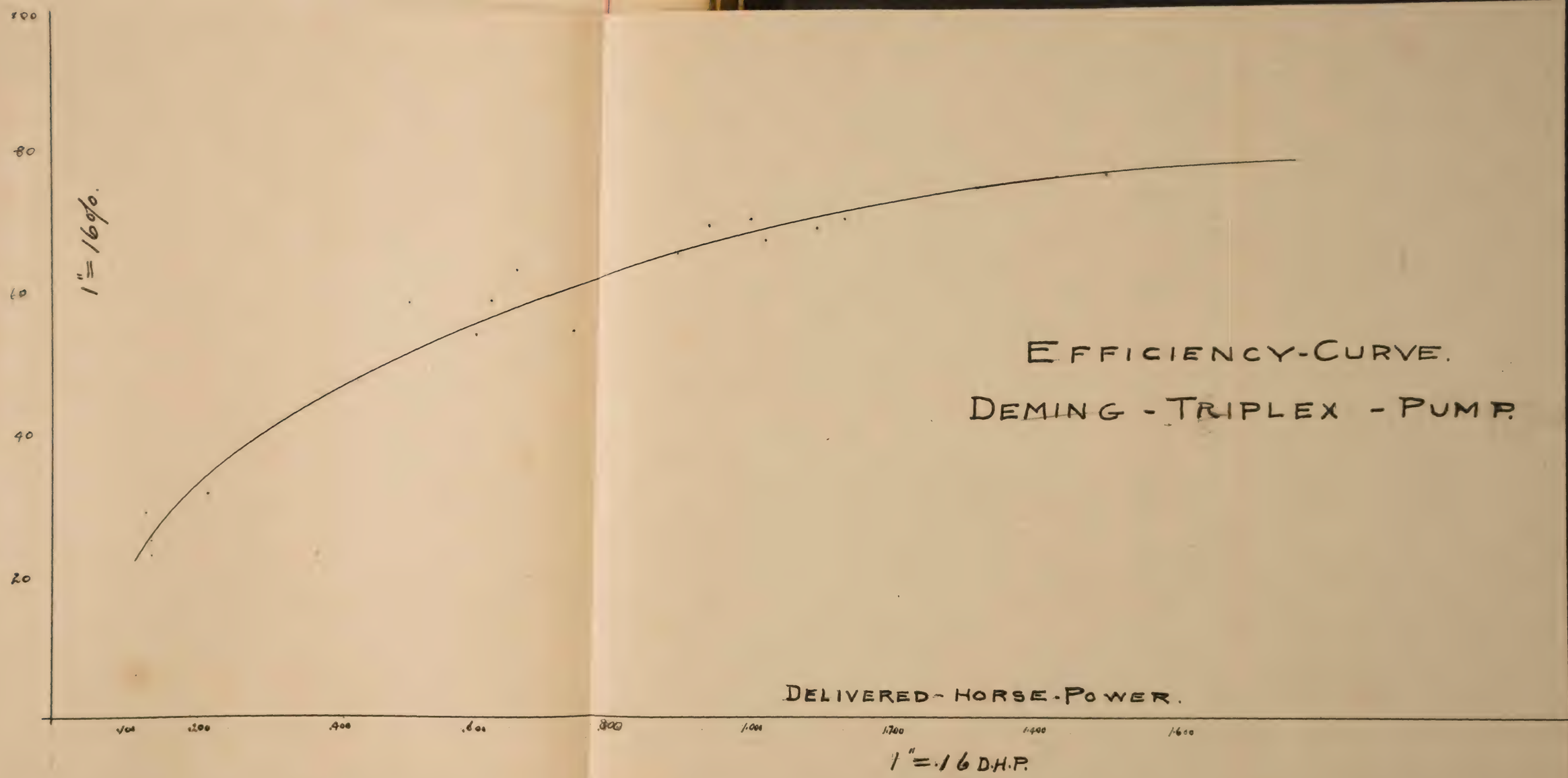
Total Head 136.5'

Log and Data of Tests.

No. of Test	Date	Duration	Rk. Point	Temp. Water	R. P. M. (Pelton)	R. P. M. (motor)	Field Current	Armature Current	Torque	Torque Corrected	Head in Water	Vacuum	Quantity per sec.	Total Head
1	Apr. 4. 64.	50	8	54	43.7	1224	.65	14.2	5.87	50.8	.075	16	.058	136.5
2	4-11-04	25	9	50	46.7	1304	.60	7.64	2.16	0	.078	16.4	.0612	19.55
3	"	25	9	50	46.8	12784	.58	8.85	2.715	4.54	.0786	16.76	.0618	30.42
4	"	25	10	50	49.1	1393	.51	11.01	3.385	15.6	.0818	18.1	.0656	57.45
5	"	25	10	50	49.8	1397	.52	12.54	4.19	25.7	.082	18.04	.0658	80.67
6	4-16	20	9	65	40.8	1145	.54	16.9	6.99	74.1	.066	16	.0476	189.9
7	"	26	10	65	45.04	1263	.52	13	4.4	35.8	.0775	17	.0605	102.85
8	4-18	25	10	74	47.8	1340	.516	14.96	5.31	44.7	.0775	16.5	.0605	122.68
9	"	20	10	74	47.65	1335	.50	16.01	5.62	54.5	.0775	16.88	.0605	146.8
10	"	23	10	74	47.49	1332	.505	17.53	6.38	64.5	.0768	16.6	.0596	168.6
11	4-23	18	9	68	46.7	1290	.596	7.	1.806	0	.0735	17	.0558	20.25
12	"	20	9	68	45.5	1277	.58	10.43	3.53	25.7	.0735	17	.0558	79.5
13	"	12	9	68	44.89	1260	.516	14.60	6.64	57	.0725	17.45	.0547	152.05
14	"	15	9	68	47.3	1328	.574	17.29	7.	838	.0725	17.26	.0547	213.8
15	4-25	15	9	62	44.6	1250	.56	20.21	8.28	97.3	.072	17.76	.0541	245.4
16	"	20	12	62	56.94	1597	.388	12.14	3.42	26.2	.0863	17.92	.0711	81.7
17	"	10	12	62	56.2	1575	.38	16.96	5.32	54.4	.085	17.88	.0695	139.65

LOG AND DATA OF TESTS. (CONTIN.)

No. of test.	S. H.P.	D. H.P.	I. H.P.	F. H.P.	% Friction Loss.	% Hydraulic Loss.	Mech. Effic.	Hydraulic Effic.	Total Effic.	Capacity in Gals. per 24 hrs.	% Slip.
1	1.137	.901	.965	.405	29.6	6.7	70.4	93.3	65.7	37,500	8.66
2	.537	.1358	.1731	.3639	67.8	21.5	32.2	78.5	25.3	39,550	9.77
3	.672	.2135	.317	.3553	52.8	32.6	47.2	67.4	31.8	39,950	9.22
4	.895	.428	.5045	.3435	43.8	15.1	56.2	84.9	47.7	42,350	9.32
5	1.115	.604	.676	.439	39.4	10.6	60.6	89.4	54.2	42,500	9.18
6	1.526	1.027	1.243	.283	18.5	17.5	81.5	82.5	67.2	30,730	19.95
7	1.06	.623	.781	.279	26.3	20.2	73.7	79.8	58.8	39,100	9.55
8	1.357	.742	1.004	.348	25.6	26.5	74.4	73.5	54.7	39,100	13.1
9	1.43	1.003	1.124	.306	21.4	10.7	78.6	89.3	70.3	39,100	12.7
10	1.623	1.14	1.322	.301	18.5	13.8	81.5	86.2	70.3	38,500	13.7
11	.4435	.1283	.1754	.2683	60.5	26.8	39.5	73.2	28.9	36,080	16.8
12	.858	.504	.561	.291	33.9	11.3	66.1	88.7	58.7	36,080	15.7
13	1.355	.944	1.043	.312	23	9.6	77	90.4	69.6	35,170	16.75
14	1.771	1.325	1.56	.211	11.9	15.2	88.1	84.8	74.7	35,170	30.1
15	1.976	1.508	1.648	.278	14.06	11.2	85.94	88.8	76.4	34,950	16.6
16	1.042	.66	.749	.293	28.1	11.8	71.9	88.2	63.4	45,900	14.2
17	1.6	1.102	1.208	.392	24.5	8.7	75.5	91.3	69	44850	15



EFFICIENCY-CURVE.

DEMING - TRIPLEX - PUMP.

TEST # 11

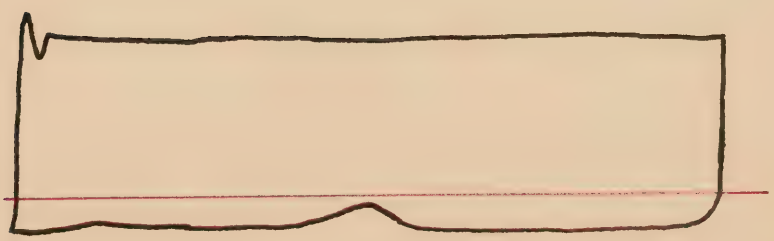
CYL # 3

A = .795
L = 3.85

TEST # 7

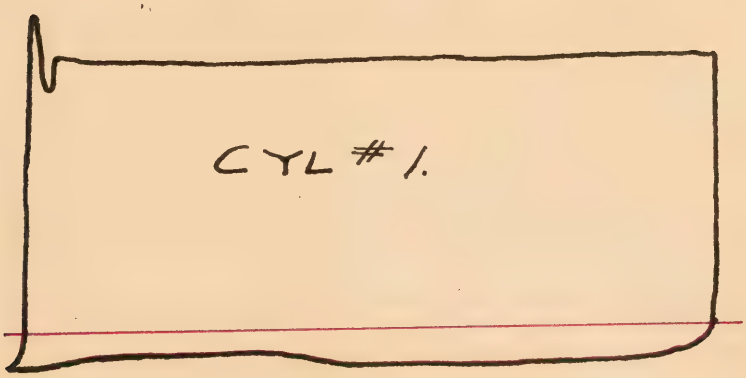
A = 3.66
L = 3.76

CYL #1.



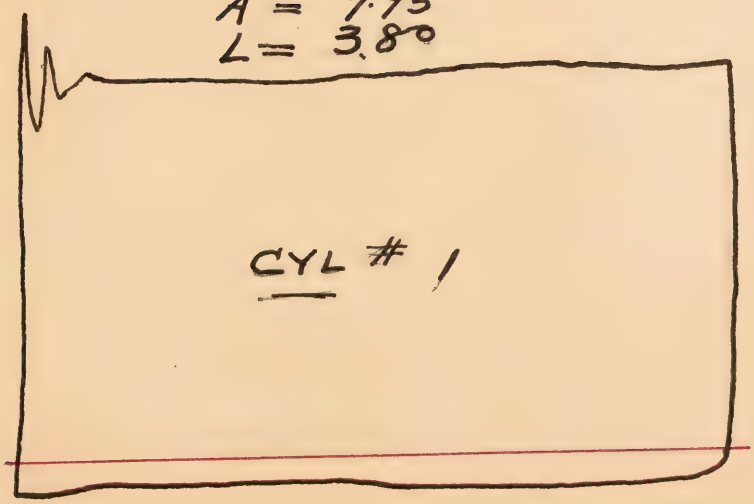
TEST # 10

A = 5.685
L = 3.74



TEST # 15

A = 7.95
L = 3.80



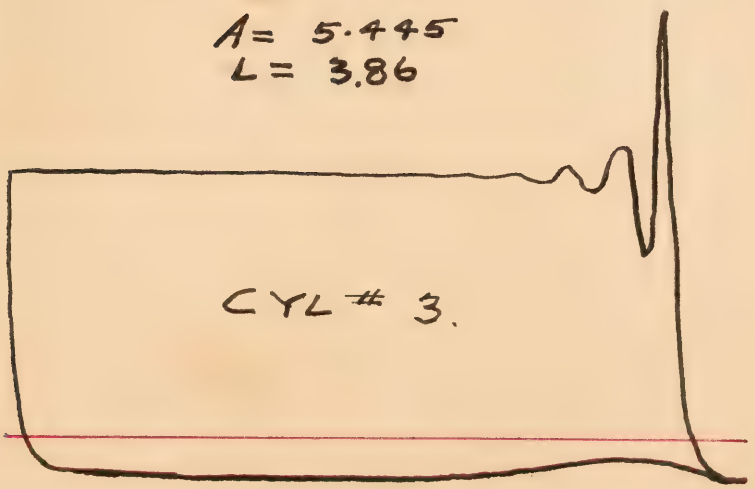
Test # 4

CYL #3

A = 1.765
L = 3.84

TEST #10

A = 5.445
L = 3.86



The curve on pag. 48 is drawn with Total Efficiencies as ordinates and D. H. P. as abscissae.

The curve shows very nicely how the efficiency increases with the load. This is what we should expect since the Friction H. P. increases very slowly with the load, while the hydraulic losses should show little increase since the velocity is practically constant at all loads.

The greatest efficiency was reached at the greatest load tested, about 70 % of full load, viz. 76.4 effic.

From the appearance of the curve, at full load we may expect an efficiency of about 78 or 79 % which is a very good efficiency for a pump.

The cards shown on page 49, +50 are actual cards taken during the tests and are good air samples. Those on page 50 show how well the pump utilizes the power supplied to it and how the higher frequency at high loads than at small loads were the presence of air seem to cut down the area of the cards considerably.

The lower card page 50 indicates a very small strain on the spring, but the spring used was the only light one obtainable, in addition to the two on the other cylinders.

The top card on page 51 shows the presence of air in the cylinder. The lower one shows that there is of the water wooden shock at entrance into the cylinders

3 1198 03070 5946
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E378.748 POS1904.3

FOR REFERENCE

NOT TO BE TAKEN FROM THIS ROOM

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